NO-RISK COGENERATION

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ABSTRACT

Cogeneration facilities, also called combined heat and power (CHP), typically achieve thermal efficiencies of 80-85 percent. The most efficient conventional electric generation plants typically do not exceed thermal efficiencies of 50 percent. The key to cogeneration's efficiency is the availability of a sizable "heat load." A heat load is the requirement for heat, usually in the form of steam, used in the manufacture of a product, such as in the refining of oil, production of chemicals, or the processing of food. Although electric power equipment is available to anyone with sufficient capital, sizable heat loads are relatively scarce. Therefore, the availability of a heat load is the determining factor for achieving the superior efficiencies and resulting superior economics of cogeneration facilities. All economically viable cogeneration projects typically must satisfy heat loads of sufficient size, so that all engine exhaust can be absorbed by the facility's processes. Succinctly, efficient and economically cogenerated electric power production is a slave to its heat load.

A large heat load that is not being used also to produce electric power is a valuable, but wasted, asset that can pay its owners substantial dividends. The purpose of this article is to demonstrate how heat load owners can extract the wasted value of a heat load without contributing capital, or assuming risk in the construction of a cogeneration facility.

FINANCIAL ASPECTS

Electric Power Income

A cogeneration (CHP) facility can derive income from many different sources simultaneously. Portions of the electric power generated can be sold to many customers. First, the plant supplying the heat load and served by the cogeneration facility can most certainly consume some of the power. Second, many states allow excess power to be sold to nearby neighbors through privately owned low voltage distribution lines. This strategy is particularly attractive if the cogeneration facility is located within an Industrial Park. Third, the local electric utility is legally required by PURPA (Public Utility Regulatory Policy Act) regulations to pay for power from a qualified facility (QF) at the utility's avoided cost, usually about 3 cents per kilowatt-hour. A QF is simply a cogeneration facility that meets certain federal efficiency requirements. Finally, if the power produced is in excess of about 100 megawatts, it can be sold to the local utility, or wheeled through the local utility's high voltage transmission lines to a suitable wholesale customer at contracted prices. Any of the above transactions can occur during the year or life of the facility, to maximize income from a portfolio of potential transactions

Heat Load Income

The local plant is expected to consume the major portion of heat produced by the cogeneration facility. Unlike electric power, markets for excess heat suffer from the limitations imposed by the distances that heat can be economically transported. For example, excess steam can be economically delivered only a distance of about 300 yards, hot water perhaps 200 yards, and hot air about 100 yards. These estimates should be considered rules of thumb only, and should be calculated for specific situations, taking into account the cost of the transporting pipe, insulation, and flow pressures, temperatures, and volumes.

However improbable, heating needs outside the facility should always be explored with nearby neighboring plants, especially if the cogeneration facility is located in an Industrial Park setting with many conveniently located potential customers.

SUBSIDIES AND CREDITS

An important source of income can be derived from certain specific federal, state, and local laws providing tax subsidies and credits, depending upon which fuels are used, and which combination of subsidies and credits are selected. Renewable fuels, such as biofuels and waste fuels, currently enjoy favored status in federal tax law and in many states.

Figure 1 summarizes the potential income sources to the facility owner of a cogeneration facility.

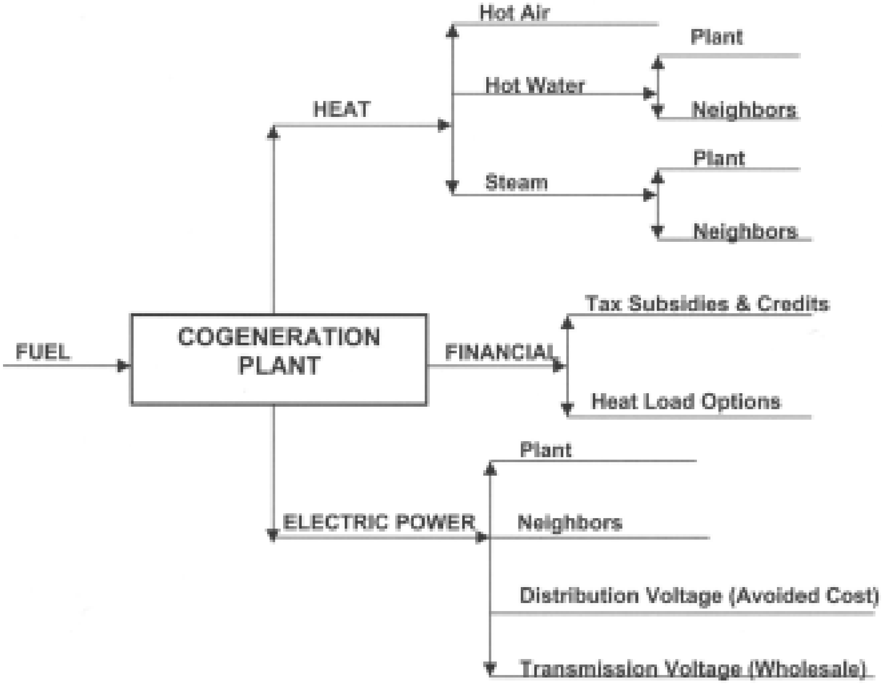

Figure 1. Buyer's Income Sources

HEAT LOAD SALE

Finally, if the heat load owner elects, for any reason (such as a lack of capital) not to build the cogeneration facility himself, he can settle for selling the heat load to a third party. This no-risk approach allows the heat load owner to participate in the favorable economics of cogeneration without the necessity of supplying capital or assuming risk.

The heat load buyer receives the dual benefits of superior thermal efficiency combined with lower project costs by avoiding the expense of a condenser, a significant cost in the construction of a conventional power plant. Figures 2 and 3 compare the two most common conventional power plant configurations with the two most common cogeneration configurations. The heat load seller can extract value from the buyer in the form of cheaper electric power, cheaper steam, a lump sum payment, or any combination of the three. The seller can, therefore, without risk extract value from the unused asset.

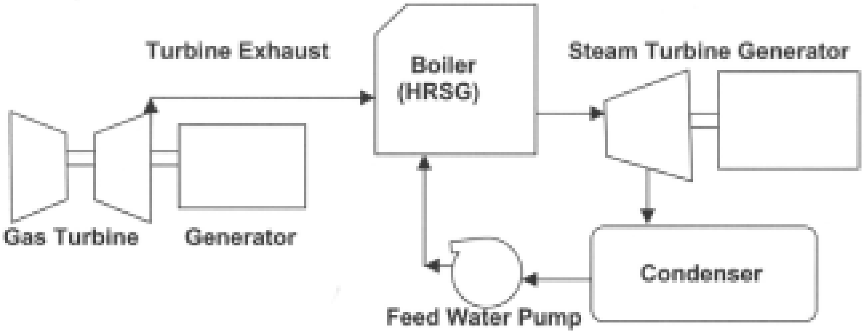

Figure 2a. Combined Heat and Power Plant

The *Combined Cycle Power Plant* directs the hot and voluminous exhaust gases from a gas turbine into a special boiler called a "heat recovery steam generator" (HRSG), to make steam for a steam turbine to generate power. The gas turbine generates about 80% of the total power produced, and the overall fuel efficiency is about 50%, compared to about 40% for the best utility steam plants described in Figure 3.

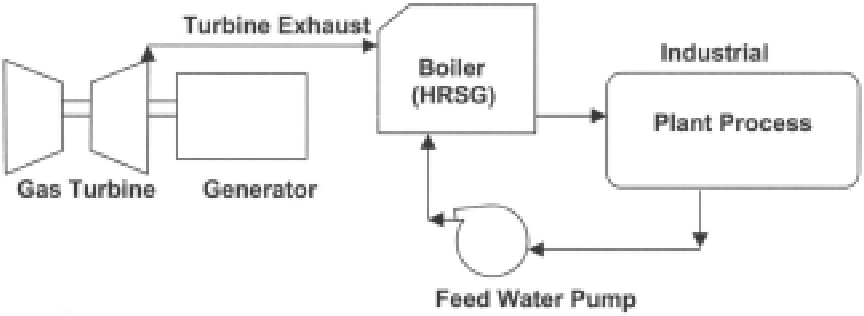

Figure 2b. Gas Turbine Cogeneration Plant

The *Gas Turbine Cogeneration Plant* is the most common type of cogeneration installation today. The gas turbine produces electric power while its hot exhaust gases are channeled into a heat recovery boiler (HRSG) to produce steam for use in an industrial process. Because the process is used as the condenser, that cost is avoided. Fuel efficiencies of 80% are common, compared to the 50% thermal efficiencies possible in the best combined cycle electric power plants. However, economic power generation is constrained by the amount of steam the process can absorb. This configuration produces about 4 lb. of steam per kWh produced, and is favored for maximizing electric power production for a given heat load.

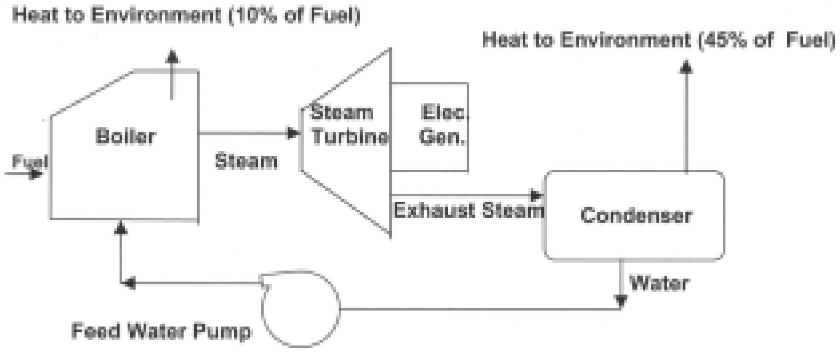

Figure 3a. Standard Fossil Fuel Plant (Fuel Efficiency = 40%)

High-pressure steam from the boiler turns an electric generator. Low-pressure exhaust steam exits the steam turbine and is condensed by cooling it with river water or air. About 40% of the fuel fed into the boiler is converted to electricity in a well run, efficient utility plant of this configuration.

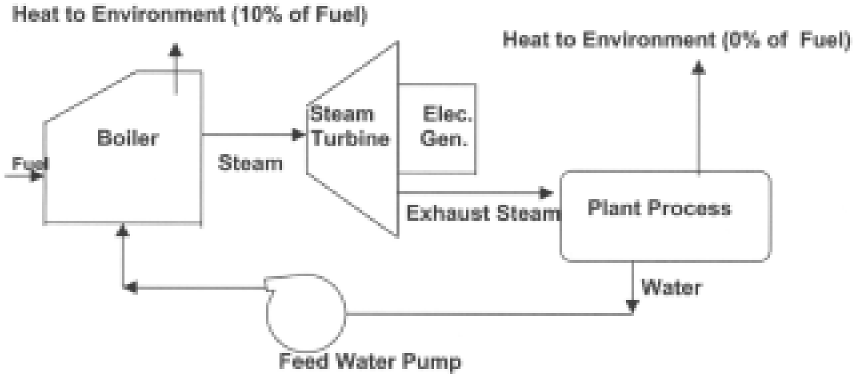

Figure 3b. Cogeneration Fossil Fuel Plant (Fuel Efficiency = 80%)

A cogeneration power plant is almost identical to a standard utility plant, except the condenser is replaced by the industrial plant's need for low-pressure process steam. Industrial plants must produce process steam to heat chemicals, cook food, and otherwise serve its processes. Fuel efficiency can easily exceed 80%. A cogeneration plant can thus avoid the very expensive condenser cost, and keep its cogeneration plant capital costs down. This configuration produces about 25 to 35 lbs. of steam per kWh produced.

The cash flow spreadsheet in Figure 4 is a financial model useful to both a heat load buyer and seller in negotiating how the value of the heat load will be distributed. The goal of the spreadsheet is to arrive at the after-tax internal rate of return (IRR).

Both buyer and seller will, in some way, construct a cash flow model. A rational buyer will want to quantify the expected economic returns on the project, and how much he can compensate the seller for the use of the heat load. The seller must also model the project's

Year	0	1	2	3	4	5
COGENERATION FACILITY INCOME						
Electric Sales						
Plant		XXX	XXX	XXX	XXX	XXX
Direct Sales to Neighbors		XXX	XXX	XXX	XXX	XXX
Sales @ Avoided Cost		XXX	XXX	XXX	XXX	XXX
Wholesale		XXX	XXX	XXX	XXX	XXX
Heat Sales						
Hot Air		XXX	XXX	XXX	XXX	XXX
Hot Water-Plant		XXX	XXX	XXX	XXX	XXX
Hot Water-Neighbors		XXX	XXX	XXX	xxx	XXX
Steam-plant		XXX	XXX	XXX	XXX	XXX
Steam-Neighbors		XXX	XXX	XXX	XXX	XXX
TOTAL INCOME		XXX	XXX	XXX	XXX	xxx
COGENERATION FACILITY EXPENSES						
Electric Power-Standby/Supplemental		XXX	XXX	XXX	XXX	XXX
Fuel Bill						
Fuel #1		XXX	XXX	XXX	XXX	XXX
Fuel #2		XXX	XXX	XXX	XXX	XXX
Operation and Maintenance Expense		XXX	XXX	XXX	xxx	XXX
Ash Disposal Cost		XXX	XXX	XXX	XXX	XXX
Insurance		XXX	XXX	XXX	xxx	XXX
Ad Valorem Taxes		XXX	XXX	XXX	XXX	XXX
TOTAL EXPENSES		XXX	XXX	XXX	XXX	XXX
COGENERATION PROFITS		XXX	XXX	XXX	XXX	XXX
Depreciation (negative)		XXX	XXX	XXX	XXX	XXX
Tax Subsidies		XXX	XXX	XXX	XXX	XXX
TAXABLE INCOME		XXX	XXX	XXX	XXX	XXX
State & Federal Income Taxes (negative)		XXX	XXX	XXX	XXX	XXX
Add back: Depreciation		XXX	XXX	XXX	XXX	XXX
Tax Credits		XXX	XXX	XXX	XXX	XXX
Investment (negative) & Salvage Value	XXX					XXX
AFTER TAX CASH FLOW	XXX	XXX	XXX	XXX	XXX	XXX
CUMULATIVE A.T. CASH FLOW	XXX	XXX	XXX	XXX	XXX	XXX
FINANCIAL INDICATORS:						

COST OF CAPITAL	**AAA**	**PRESENT VAL. @**	**AAA**	**DDD**
INTERNAL RATE OF RETURN	**BBB**	**INVESTMENT**		**XXX**
YEAR THAT PAYBACK IS ACHIEVED	**CCC**	**NET PRESENT VALUE**		**FFF**

Figure 4. Example Cash Flow Analysis

cash flows to quantify the amount of compensation that he can extract before the buyer's IRR deteriorates to the buyer's "hurdle rate." The hurdle rate is an after-tax IRR below which the buyer becomes indifferent as to whether he embarks on the project. It's usually about 15 percent, assuming the project is 100% owner financed (no debt). In other words the seller must ensure that he obtains the maximum value for his heat load, while preserving an attractive economic return (IRR) for the buyer. Figure 5 diagrams this relationship and identifies the economic zone where negotiations can occur.

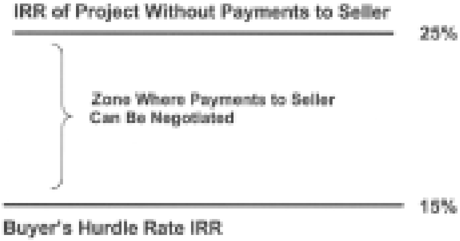

Figure 5. Negotiating Diagram Example [Internal Rate of Return (IRR) of Heat Load Buyer]

QUANTIFYING HEAT LOAD VALUE

The most common situation occurs when a buyer desires to construct a cogeneration facility within a relatively short time, such as 3 years. The spreadsheet cash flow model above will accurately quantify the heat load's short-term value. It is simply the amount that is added to the project's capital cost, which will bring the project's IRR down to the buyer's hurdle rate.

For projects further out in the time horizon, such as beyond 3 years, a heat load option approach works best. A heat load option is the right, but not the obligation, to supply a heat load at a certain price or pricing structure. Heat load options are like any other option traded on the Chicago Board of Options Exchange (CBOE). Options can be assigned a cash value, and can be assigned (sold to other parties). Like traded stock options their value rises or falls depending upon such factors as:

1. Risk free interest rate on money,
2. Volatility of the expected returns, and
3. Time remaining before the option expires.

In other words, its value is in conformity with the Black-Scholes Option Pricing Model (OPM) routinely used on the CBOT (Chicago Board of Trade) to determine stock option values. But there are important distinctions. A heat load is not a fungible commodity. Some heat loads are worth more than others. For example, the ideal heat load would be very large (in excess of 100,000 lb. of steam per hour), and would be available 24 hours per day, 7 days per week, all year, at a consumption level that never varies. Few real world heat loads can meet these requirements. In addition, the heat load options market is not "economically efficient." The value of each option must be negotiated, often between buyers and sellers who have unequal levels of knowledge. The Black-Scholes Option Pricing Model requires a simulation, designed to reveal market volatility, for insertion into its formula, whereas the Binomial Method requires more human judgment. Both will produce results that are reasonably close. Regardless of the method used, all should be considered estimates only.

THE SELLER'S VIEW

All of the preceding discussion focused on the negotiating process tools that assist both buyers and sellers in rationally and expeditiously arriving at agreement. These tools were also tailored to the assumptions that the seller would contribute no capital and assume little or no cogeneration project risk. However, the value that the heat load seller extracts can be much greater than the direct payments delivered by the buyer. The seller's avoided costs such as the near-term requirement to replace an aging and inefficient boiler, and boiler operational costs, typically borne by the cogeneration facility owner, can easily become multi-million dollar savings, even for a small heat load. Avoided production losses because of higher electric reliability, although intangible, can be approximately quantified, and are also a substantial incentive. Somewhat offsetting these cost savings is the requirement for backup electrical power supplied by the local utility. Finally, the local utility, if it already has substantial excess capacity, may be persuaded to offer significant discounts to the seller, to defer the project to prevent even more excess power from entering the electric market. Of course, all such projects must be fully justified and present detailed project cash flows for the utility's Public Service Commission approval. Figure 6 summarizes all of the potential income and value sources of the heat load seller.

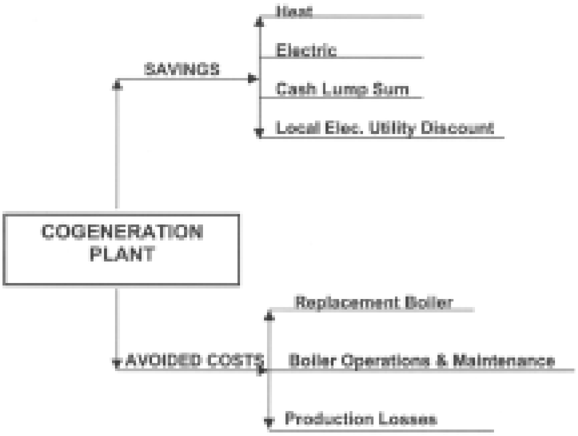

Figure 6. Seller's Cogeneration Income Sources

CONCLUSION

Any owner of a large heat load can potentially extract value without risk by offering the heat load to a third party developer. Direct payments by the buyer to the heat load seller can be substantial, but can be further amplified when the seller's avoided capital costs, operational costs, and avoided production losses are included.

ABOUT THE AUTHOR

Yeager Vogt is president of Xander Corporation, a consulting company, founded in 1987, providing utilities conservation services in the areas of electric energy, fuels usage and procurement, telecommunications, and water. Mr. Vogt has a B.S. in mechanical engineering from Columbia University and an MBA from Tulane University. He has worked for Procter and Gamble as a utilities and materials conservation engineer, at Domino Sugar as manager of energy conservation, and at Entergy Corporation, where he served as director of technical services and joint ventures. At Entergy he formulated the precision pricing policy for determining electric power discount offers to large industrial customers. He is the author of numerous articles on financial energy options, transmission deregulation, organizational behavior, and energy modeling using various techniques, including artificial intelligence (AI). He can be reached through e-mail at gvogt1@cox.net.